NASA TECHNICAL TRANSLATION NASA TT F-12,909

COMPARISON OF THE ABSORPTION DISTRIBUTION IN THE CH_4 BAND AT 6190A ON THE DISKS OF JUPITER AND SATURN

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Translation of "Sravnenie Raspredeleniya Pogloshcheniya V Polose CH_4 6190A Na Diskakh Yupitera I Saturna," IN:

Fizika Planet. Trudy Astrofizicheskogo Institute. Academiya Nauk Kazakhskoy SSR, Tom IX. (Planetary Physics. Transactions of the Astrophysics Institute. Academy of Sciences, Kazakh SSR, Vol. 9). "Nauka" Press, Alma-Ata, 1967, pp. 59-62.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 MAY 1970

NASA TT F - 12,909

COMPARISON OF THE ABSORPTION DISTRIBUTION IN THE CH_4 BAND AT 6190A ON THE DISKS OF JUPITER AND SATURN

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Abstract. Preliminary results are given involving an investigation of molecular absorption distribution on the disks of Jupiter and Saturn, obtained in 1964 with a 70 cm telescope. The spectrograms of Jupiter and Saturn are examined in relative intensity in the CH_4 band at 6,190 A is given for the central meridians of Jupiter and Saturn.

Preliminary results are given in this article on investigations of the distribution of molecular absorption over the disks of Jupiter and Saturn which were begun in 1964 on the AZT-8 70 cm telescope by means of the ASP-21 diffraction spectrograph with dispersion 30 A/mm. The characteristics of absorption distribution over the Jovian disk has been discussed repeatedly in a whole series of works. At the same time it seems important to clarify whether there is any significant difference in the distribution of methane absorption over the disk of Saturn, which in size is the second representative of the group of giant planets. Up to the present time we have had only the data of Hess [1], who observed Saturn in 1950 with the aid of a 3-Prism spectrograph with dispersion 43 A/mm between the C and D lines. Hess obtained three spectrograms each of the equatorial zone of Saturn, and the northern and southern hemispheres (zenographic latitudes 5°S, 45°N and 55°S, respectively). On the equator he obtained an equivalent with the CH_4 absorption band at 6,190 A equal to 23.2 A, in the southern hemisphere 27.2 A and in a northern hemisphere, 28.2 A. In contrast to the results for Jupiter, /59*

*Numbers in margin indicate pagination in foreign text.

the methane absorption over the Saturn disk, according to Hess, increased with latitude.

According to these data, however, it is difficult to judge absorption behavior along the central meridian of Saturn. The only thing that can be said is the fact that the change in absorption from the equator to the poles of Saturn still does satisfy the usual increase in the optical path of light in the atmosphere proportional to sec ϕ. Therefore Hess assumes an increase in the level of the upper boundary of the cloud layer toward the poles of Saturn by 5-8 km.

During the summer of 1965 at the observatory of the Astrophysical Institute the author obtained several series of spectrograms of Jupiter and Saturn with the 28-m AZT-8 Cassegrainian focused telescope. The slit of the spectrograph during the photographic operation was oriented along the equator or the central meridian of each planet. The duration of the exposure on the A-700 film for Jupiter was 10-15 minutes and one hour for Saturn with a spectrograph slit width of 0.07 mm. The equatorial diameter of the image of Jupiter (the width of the spectrogram) was 3.3 mm, and that of Saturn--1.7 mm. Examples of the spectrograms are shown in Figures 1 and 2.

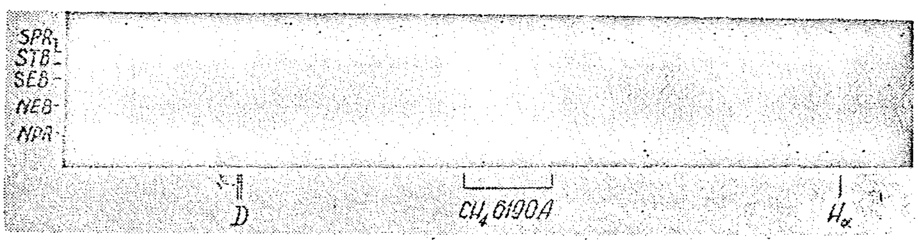

Figure 1. Spectrogram of Jupiter (Central Meridian) in the Region λλ 5,700-6,750 A. The Main Bands on the Jovian Disk are Shown on the Left.

On the spectrograms the intensity distribution was measured in a direction across the dispersion in the center of the methane absorption band I_{ab}(λ 6,190 A) and in an adjacent segment of the continuous spectrum I_{co}(λ 6,300 A). The processing method was completely identical to that described in [2]. The height of the inlet slit of the MF-2 microphotometer corresponded to a spectrosegment of less than 10 A (absorption band width is equivalent to 150 A for Jupiter and is equivalent to 160 A for Saturn). /60

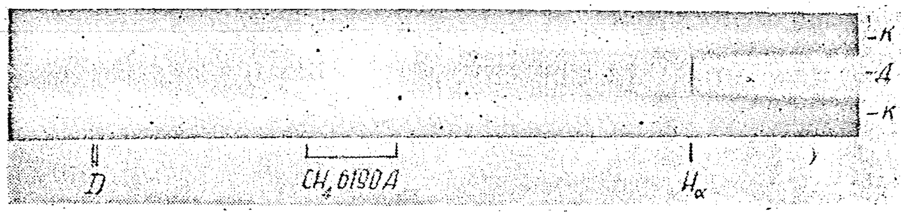

Figure 2. Spectrogram of Saturn (Equator) in the Region λλ 5,850-6,750 A. To the Right are Noted the Disk and Ring Openings of the Planet.

Figure 3 shows average curves of log I_{ab}/I_{co} variation along the equator (7 spectrograms) and the central meridian (7 spectrograms) of Jupiter and along the central meridian of Saturn (4 spectrograms). Measurements along the equator of Saturn were unsuitable for further processing since the image of the ring was superimposed on the limb of the disk; the angle of opening of the ring during the period of observations was very small (2°.6-4°.3).

On the Jovian disk absorption on the CH_4 band at 6,190 A falls toward the edges of the disk at the equator and toward the poles on the central meridian. On the equator the reduction in absorption toward the edges occurs smoothly but a small amount of asymmetry is observed in absorption behavior in the eastern and western directions: the reduction in absorption toward the western limb occurs somewhat more rapidly than toward the eastern limb.

Absorption distribution along the central meridian has amore complex nature. First of all we observe near the center of the disk clear but low-order variations in the intensity of the methane absorption band. In the northern hemisphere absorption decreases toward the pole more smoothly than in the southern hemisphere, where absorption first increases from r/R = 0.3 to r/R = 0.8, and then falls rather sharply.

Absorption behavior along the central meridian of Saturn qualitatively shows practically no difference from that observed on Jupiter. Absorption falls toward the poles of the planet, in contrast to the results obtained by Hess. The reduction in methane absorption is also revealed near the equator of Saturn. But in all probability this is not real and is caused by the overlapping of that part of Saturn's ring which is turned toward the Earth and which intersects the planetary disk almost along the equator. The reduction in absorption toward the poles occurs somewhat more steeply than for Jupiter.

Such are the qualitative results of spectrophotometric absorption measurements in the CH_4 band at 6,190A on the disks of Jupiter and Saturn. We shall make certain quantitative evaluations.

On the equator at the center of the Jovian disk $\log I_{ab}/I_{co} = -0.170$, /61
while at the distance $r/R = 0.87$ ($\sec \vartheta = 2$) $\log I_{ab}/I_{co} = -0.140$ in the eastern hemisphere and $\log I_{ab}/I_{co} = -0.105$ in the western hemisphere. This means that the depth of the methane absorption band equals $R_E = 0.93\ R_0$ and $R_W = 0.86\ R_0$, where R_0 is the depth of the band in the center of the disk. Since the equivalent width (total absorption) of the CH_4 band may, with sufficient accuracy, be considered to be proportional to the depth of the band, $W_E = 0.93\ W_0$ and $W_W = 0.86\ W_0$. Accepting in agreement with [3] that $W_0 \simeq 19A$, we find that $W_E \simeq 17.5$ A and $W_W = 16.5A$. These values have, of course, only an illustrative nature but they indicate the insignificance of the reduction in absorption toward the edges of the Jovian disk in the equatorial zone, which does not exceed 10-13%. Asymmetry in absorption behavior along the equator may be caused by the phase effect; the phase angle of Jupiter during the period of observations changed from 9 to 11°. In this connection the evening terminator of Jupiter was observed in the western hemisphere. To give any kind of interpretation of the small degree of asymmetry in absorption distribution would be premature at the present time. Dissimilar absorption behavior in the polar region of Jupiter may be associated with certain differences in the scattering properties of the cloud layer or with the radiation cycle of the polar zones. The difference in total absorption for points with $\phi = 57°$ ($\sec \varepsilon = 2$), found in the same manner as for the equatorial zone, results in the following: $W_N = 0.90\ W_0$

and $W_S = 1.03\ W_0$, i.e., the difference lies within 10% limits. An interesting characteristic is revealed on almost all spectrophotometric profiles of the central meridian in the equatorial region. In both dark equatorial belts the absorption as a rule is somewhat greater than in the light equatorial zone decisively established in 1965 and in adjacent light tropical zones. The difference on the average amounts to $\log I_{ab}/I_{co}$ 0.025, i.e., in the dark belts absorption is approximately 5-6% greater than in light zones. This means that the dark belts in 1965 were situated somewhat lower than the light zones. The difference in altitudes, if calculated in a manner similar to that of [4], does not exceed 8-10 km in the case of a 2-layer model of an absorbed atmostphere.

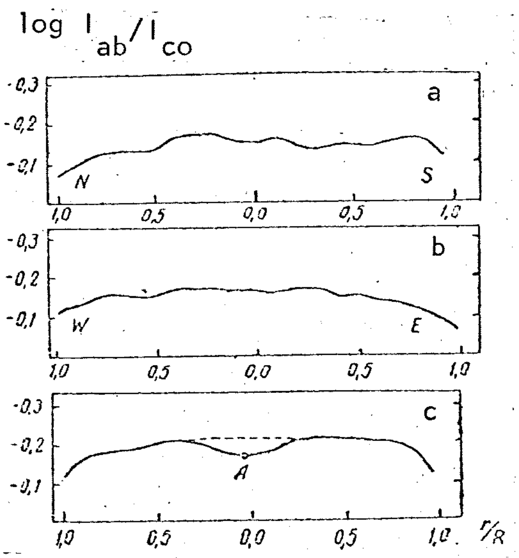

Figure 3. Relative Intensity Behavior in the CH_4 Band at 6,190 A Along the Central Meridian of Jupiter (a), the Equator of Jupiter (b) and the Central Meridian of Saturn (c).

On Saturn the difference in absorption between the center of the disk and latitude 57° amounts to $\log I_{ab}/I_{co}$ 0.040-0.045, on the average $R_{57} = 0.91\ R_0$, since the decrease in absorption toward the poles for Saturn shows practically no difference in magnitude from that obtained for Jupiter.

In 1950 the ring inclination of Saturn to the line of sight was almost the same in 1965. Therefore it cannot be excluded that the result obtained by Hess--an increase in absorption at latitudes $\sim 50°$ in comparison with the equator--is partially caused by ring overlap in the equatorial spectrograms. If we accept for the equator an absorption value which corresponds to point A on Figure 3, then at latitude 50° $R_{50} \simeq 1.08\ R_A$ and $W_{50} \simeq 1.08\ W_A$. Having accepted $W_0 = 23.2$ A for the equator, we find that W_{50} = 25.0 A. Hess found that W_0 and W_{50} was somewhat greater, so that apparently the cause of the divergence was not only associated with the effect of the ring.

In order to make final conclusions concerning the nature of the distribution of methane absorption over the disk of Saturn it is necessary to carry out similar observations at a moment when the ring is situated with the edge in respect to the Earth or in a period of illumination of the ring with solar light from the side opposite that which is turned toward the Earth, when interference from the size of the ring will be practically eliminated.

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Translated for National Aeronautics and Space Administration under contract No. NASw-2037 by Techtran Corporation, P.O. Box 729, Glen Burnie Maryland 21061